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Keynote Address:
The Regulation of Halon and Halon Substitutes

Today I want to tell you what is in the current SNAP rule which was published on March 18, and to attempt to describe the risk-balanced decision making process entailed in its development. In addition, I will discuss the other factors and programs affecting the halon phaseout.

The U.S. Clean Air Act was passed in 1990, and Title VI is the part that deals with the protection of the stratospheric ozone layer. Section 612 directed EPA to set up a program, which we call 'SNAP' or the Significant New Alternatives Policy program, to evaluate any halon substitute or alternative technology to ensure that the substitutes reduce the overall risk to human health and the environment. Our second program objective is to promote these substitutes to get them to market as quickly as possible.

The SNAP rule formally establishing our program and setting out the initial lists of substitutes was published on March 18, 1994, in the Federal Register (59 FR 13043) and became enacted on April 18, 30 days later. We plan on doing quarterly updates, so the first one will be in late June and then quarterly thereafter, e.g. September, 1994, etc. If a substitute has no regulatory conditions attached, we can publish them in the Federal Register as acceptable and the publication of the list is done for the purpose of putting the information out into the public domain. But if it requires a condition (for example in the halon sector for total flooding agents) whether it is a use condition or a narrowed use restriction, then it becomes part of the public notice-and-comment process, during which we propose it, receive public comment, and then the next quarter we would publish a final determination.

First, lets discuss EPA's risk balancing approach on health and safety issues. We look at use of the agent in each sector under likely exposure pathways. In the halon sector we look primarily at acute exposure in use, whether from discharge during a fire event or during an accidental discharge. And we also look at long term chronic exposure for a person who may be regularly doing maintenance on systems or someone who may be involved in the manufacture and filling of these systems. The manufacturers supply the data which EPA needs for the evaluation. We ask for a variety of information in order to screen for several background effects and toxicity risks to a variety of populations, including pregnant women, children, workers, etc. Most of them are benign in the likely exposure scenarios, but the main health issue that arises for these agents is their cardiosensitization profile. We look at the actual design concentration, as NFPA defines it (cup burner plus 20%) or in some cases the actual large scale testing design concentration, and compare this value to the cardiotoxic effect level.

Chart 1 shows the design concentration of the five agents which are feasible for use in occupied areas, in comparison to their cardiotoxic no observed adverse effect level (NOAEL) and lowest observed adverse effect level (LOAEL). If the LOAEL is lower, in other words, you get to that level before you get to the extinguishing design concentration, then it is not feasible for use in an occupied area, as that could lead to heart arrhythmias and possible heart attacks. In order to be useful in an occupied area, the LOAEL and NOAEL values must be higher than what the design concentration would be. But in cases where the design concentration of an actual system may approach the NOAEL or LOAEL, the protocol for doing the cardiosensitization test is conservative, and it has been estimated to be safer than what these numbers imply. EPA believes the cardiosensitization protocol to be one order of magnitude safer and the toxicologist for the US Air Force believes these numbers to be two to four orders of magnitude safer. So these are conservative numbers that represent a worst case scenario.

Beagle dogs, trained to tolerate the tests, are used in these protocols. They are supersensitized with an injection of epinephrine (adrenaline) and then exposed to set concentrations of the agents for 5 minutes. The NOAEL is the value where no effect was observed and the LOAEL is the first sign of a physiological change, such as a quickening of the heart rate. The dogs do not typically experience a heart attack and are rarely sacrificed. Thus, we believe that these protocols represent a very safe level of use. I understand that there is an effort underway in NFPA to raise the design concentration to cup burner plus 40%. I do not agree with this, because I think these numbers are already quite conservative and should be allowed to be used in these concentrations.

It is a different situation for streaming agents because we are not flooding an entire space with a consequent infusion of the gaseous agent to a proportion of the oxygen in the room. It is a localized application, and the air exchange further dilutes the concentration of the agent. So, EPA requires manufacturers to submit data acquired by personal monitoring for the anticipated usage. In this test, a device is attached to the breathing zone of a firefighter to collect samples of the actual levels of exposure. We have found that the actual exposure is much lower than what our models predict. The results of this analysis led EPA to list the HCFC Blend as acceptable, even with a low LOAEL of 2.0%. As Chart 1 indicates, the LOAEL of Halon 1211 is also low, only 1%. Halon 1211 is a relatively toxic agent in this regard, which shows that these agents can be used safely (although there are known incidents of deaths with Halon **1211)**.

We have patterned our conditions for the use of total flooding agents after current OSHA requirements for Halon 1301 systems. Because OSHA does not currently specify the acceptable exposure levels to the substitute agents, we are laying these values out very specifically in our rule. EPA will withdraw these conditions for use in the workplace when OSHA takes steps to amend their regulation. We understand that under a new streamlined regulatory process, they intend to put out an amendment, optimistically, in the next two years and certainly within the next four years.

To remind you, the conditions are as follows. If personnel cannot evacuate in less than a minute, the design concentration may not exceed the NOAEL. If personnel can evacuate in less than a minute, then the design concentration may be as high as the LOAEL. And, if the area needs a design concentration in excess of the LOAEL, then any personnel who could be potentially exposed must be able to leave the area within 30 seconds. So, for example, a machine room or a confined space may only be designed above the LOAEL if any personnel who could possibly be in the areas can escape quickly.

In the June rulemaking, EPA is planning to take examine the anesthetic effect of these agents which may be relevant in certain usages, such as onboard aircraft or in submarines, where rapid egress is impossible. We are looking at the exposure profiles of water misting systems and of powdered aerosols to anticipate, and minimize, any potential risk. For the inert gases, we are looking at minimum required oxygen levels. As you know the inert gas which is currently on the acceptable list adds CO_2 to the room, and we have two more which have been submitted which do not add CO_2.

On environmental criteria, EPA looks at ozone depletion potential. I want to point out and clarify something that has come up as a point of confusion concerning the definitions of class I and a class II substances. There is a distinction made in the Clean Air Act which specifies that any substance with an ODP of 0.2 or higher must be listed by EPA as a class I substance in the United States and must be phased out of production. So, once EPA becomes aware of it, a regulation must be written, and from the date of the regulation listing the chemical as a class I substance, it must gradually be phased out over seven years until it is completely banned from production.

As to a class II substance, by implication something with an ODP of less than 0.2, the Clean Air Act does not explicitly lay out a bottom line of what is a class II substance. It says that the EPA Administrator is to determine if a substance could significantly damage the stratospheric ozone layer. Currently the chemical with the lowest ODP that EPA has listed as a class II substance is HCFC-123 with an ODP of 0.02. That is not to say that this is the definition, but that it happens to be the lowest ODP listed. If an agent has an ODP less than 0.02, then we would have to look at its emission profile, its ODP, and its atmospheric lifetime. Potentially, EPA may not view an agent with an ODP of 0.01 or less as a class II substance. This issue has been raised in the context of CF_3I, that has an ODP lower than *0.02*, which I will discuss below.

While EPA considers other environmental media besides ozone depletion potential, including aquatic toxicity, air pollution, etc., global warming potential (GWP) and atmospheric lifetime are the other key issues in evaluating halon substitutes. President Clinton's Climate Change Action Plan was released November, 1993. It contains a specific action item, action #40, which specifically points to EPA's SNAP program and directs EPA to minimize unnecessary emissions of greenhouse gases. This is viewed as one way to meet the national goal of reducing emissions in the year 2000 to 1990 levels. Consequently, EPA attempts to take a risk balanced approach between ODP and GWP, and the related atmospheric lifetimes of these agents. As chart 2 shows, EPA's dilemma is that agents with no ODP tend to be moderate to high global warmers, and agents with some ODP tend to be low global warmers. (When we talk about an ODP, it is relative to CFC-11, but when we talk about GWP, it is relative to CO_2.) So, the keyword in our program is risk balance. We have attempted to characterize emission levels and exposure routes in order to spread the risk and balance the environmental impacts. We decided to look for the outliers. Obviously the PFCs are outliers, with atmospheric lifetimes in excess of 3,000 years, and which are virtually indestructible. On HFC-23 with a 300 year lifetime, we decided to pass on it as it is a byproduct of the manufacture of HCFC-22, and even after HCFC-22 is phased out of production in the year 2020, we can expect HFC-23 to continue to be produced as a byproduct of the manufacture of polymers such as teflon. In addition, Action 41 of the Climate Change Action Plan is a voluntary agreement with the manufacturers of HCFC-22 to cut emissions of HFC-23 by 50% by the year 2000. So, since this agent would be emitted anyway, we thought it should be put to some societal use by capturing and putting it in a tank for fire protection. Thus, we removed the restrictions placed on this agent in the proposed rulemaking.

In the final rulemaking, we have placed a narrowed use restriction on PFCs, allowing it to be used only where no other agent is technically feasible due to safety or performance requirements. In other words, it may only be used if no other agent will meet the technical requirements for the application, or where the concentration of other agents would exceed the conditions for cardiotoxicity which I have described here. The user would conduct an evaluation, document it, and keep it on file -- no need to come to EPA for any approval. But we expect people to take our restriction seriously and use PFCs wisely.

Upcoming work on environmental issues include work to implement Action 40 of the Climate Change Action Plan to reduce unnecessary emissions of greenhouse gases. We are attempting to do this through industry based practices rather than through regulation. We are working with industry right now to do an evaluation of emissions. In 1986, the Halon Technical Options Committee did a study and figured out that 85% to 90% of all halon emissions were in non-fire events, e.g. accidental discharges, testing, training, leakage, etc. Industry has since then changed a lot of those practices, so we are now attempting to characterize current emission levels, and we are looking to see what other industry practices can be changed to lower unnecessary emissions further. Hopefully, should global warming regulation become a reality in the future, we can show that this industry has really rounded up the wagons in that these chemicals are used because they are necessary for life safety and property protection, and that there is not widespread unnecessary emissions.

Concerning the CF_3I work in progress: as you know there is the ad hoc task force being headed by Charles Kibert for the U.S. Air Force, there is a lot of work being done by Wright-Patterson AFB, and NMERI is very involved in researching this agent. The question has arisen on whether CF_3I has an ODP. A calculation was performed indicating that its ODP could be as high as 0.011, which is not too far from 0.02, which is the lowest ODP currently classified as a class II substance. That surprised us because we know that its atmospheric lifetime is 1.15 days because it breaks down in the presence of light. We thought that something with such a short lifetime could not get up into the stratosphere. The estimated ODP was developed using an assumption that 5% of this agent would very quickly get up into the stratosphere in the presence of a vertically turbulent weather pattern. In fact, this would only occur at the equator, so the 5% number is an over-exaggeration. Because not all the information needed to calculate the ODP of iodine is available, NIST has undertaken to develop the rate constants to more accurately characterize its reaction. Simultaneously, the US Army, under the auspices of the Department of Defense, has undertaken work to improve the 3-dimensional modeling, to give a more accurate picture of its effects, and especially of its effects when released at altitude from aircraft. EPA believes that the results of the new calculations will prove that the estimated ODP of 0.011 is overstated. In addition, we are looking at the historical emission levels of halon from military and commercial aircraft. Early analysis indicates that historically very little halon was discharged at any altitude, much less near the stratosphere. Thus, even if CF_3I has an ODP of 0.01, if only 1,000 pounds a year reaches the stratosphere EPA would probably not consider it a class II substance.

Charts 3, 4 and 5 show the agents listed as acceptable in the SNAP rule, and Chart 6 shows the agents currently listed as pending and which will be treated in the June rulemaking.

Finally, I want to point out that EPA fully supports halon banking, including the Halon Recycling Corporation, the DOD Halon Reserve, and the UN Environment Programme's Halon Clearinghouse. There are no restrictions either under the Montreal Protocol or in the Clean Air Act prohibiting the use of recycled halons, or requiring reporting of halon emissions. The accelerated phaseout can be softened by judicious transfer of existing halon to those applications which prove more technically difficult or more costly to change over to the new agents in the short term.

EPA is trying to approach the halon phaseout and the search for substitutes with a collaborative attitude with industry. We hope that EPA's involvement is successfully helping to clear out the underbrush in order to facilitate transition into the use of the new chemicals.

CHART 1

HEALTH AND SAFETY CHARACTERISTICS

AGENT	DESIGN CON.	NOAEL	LOAEL	OTHER
TOTAL FLOODING AGENTS				
Halon 1301	3.4	7.5%	10.1%	
HFC-23	14.4	30%	>30-50%	min. O2 level
HFC-227ea	7.0%	9.0%	>10.5%	
C4F10	6.6%	40%	>40%	min. O2 level
HCFC Blend A	8.6%	10.0%	>10.0	
IG-541	min 12% O2, Max 5% CO2			Min 10% O2; Max 5% CO2
STREAMING AGENTS				
Halon 1211		[illegible]		
Cor 14		40%	>40%	
HCFC Blend B		1.0%	2.0%	

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CHART 2

ENVIRONMENTAL CHARACTERISTICS

AGENT	ODP	100 yr. GWP	500 yr. GWP	ATMOSPHERIC LIFETIME
C i	0	1		120
TOTAL FLOODING AGENTS				
Halon 1301	10-16	5,800		70-100
HFC-23	0	9,000	8,400	300
HFC-227ea	0	2,050	736	31
C4F10	0	5,500	8,514	3,000
HCFC Blend A	0.05-0.02	90-1,600	30-540	1.6-15
IG-541	0	N/A	N/A	
STREAMING AGENTS				
Halon 1211	3-4			12118
C6F14	0	5,200	7,416	3,000
HCFC Blend B	0.02	90		1.6

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CHART 3

ACCEPTABLE TOTAL FLOODING AGENTS

FEASIBLE IN NORMALLY OCCUPIED AREAS

- HFC-23 (FE 13)
- HFC-227ea (FM 200)
- C4F10 (PFC 410) *
- [HCFC BLEND] A (NAF S III)
- [Inert Gas Blend] A (Inergen)

* restricted use

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CHART 4

OTHER ACCEPTABLE TOTAL FLOODING AGENTS

FEASIBLE IN NORMALLY UNOCCUPIED AREAS

- HBFC-22B1 (Great Lakes FM100)
- HCFC-22
- HCFC-124 (DuPont FE-241)
- HFC-125 (DuPont FE-25)
- HFC-134a (DuPont)
- Powdered Aerosol (Spectrex)
- Solid Propellant Gas Generator (Rocket Research)

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CHART 5

SUMMARY OF STREAMING AGENTS

COMMERCIAL & MILITARY USES ONLY

- [HCFC BLEND] B (Halotron I)
- HCFC-123 (DuPont FE-232)

  C6F14 (3M PFC 614) *
- HBFC-22B1 (Great Lakes FM 100)

* restricted use

CHART 6

PENDING AGENTS

<u>TOTAL FLOODING AGENTS</u>

○Water Mist (Securiplex; Yates)

○Powder Aerosols (Spectrex; Powsus)

○Inert Gas Blends (Securiplex; Minimax)

OSF6 (Discharge test agent)

○C_3F_8 (3M CEA-308; PFC-218)

○Fluoroiodocarbons (CF_3I)

<u>PENDING STREAMING AGENTS</u>

OHCFC-124 (DuPont FE-241)

○HFC-134a (DuPont)

○HFC-227ea (Great Lakes FM-200)

○HCFC/HFC Blend (NAF P III)

OHCFC Blend (NAF Blitz III)

○Powdered Aerosol/HFC or /HCFC blends
(Powsus PGA)

US Environmental Protection Agency

REGULATION OF HALON AND HALON SUBSTITUTES

Halon Options Technical Working Conference

NMERI
Albuquerque, New Mexico

May 3-5, 1994

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EPA

US CLEAN AIR ACT

SIGNFICANT NEW ALTERNATIVES POLICY: SNAP PROGRAM

- **Evaluate halon and CFC substitutes**

  Any halon substitute or alternative technology intended for sale in the US must undergo SNAP review

- **Reduce the overall risk to human health and the environment**

  Promote substitutes while controlling risk

STATUS OF SNAP RULEMAKING

- Federal Register publication date March 18 *(59* FR 13043)
- First Quarterly Update scheduled for late June
- Quarterly Updates thereafter

Health & Safety Criteria

- *acute exposure:*
  - Design concentration vs. acute cardiotoxicity
  - Developmental effects
  - Decomposition products
  - Design concentration vs. minimum oxygen level
  - Other immediate effects and impacts on ability to escape
- *long-term exposure:*
  - Chronic toxicity and carcinogenicity

AGENT	DESIGN CONC.	NOAEL	LOAEL	OTHER FACTOR
HFC-23	114.4	30%	>30-50%	rnin. 0 2 level
HFC-227ea	7.0%	9.0%	>10.5%	
C4F10	6.6%	40%	>40%	min. 0 2 level
HCFC Blend A	8.6%	10.0%	>10.0	
IG-541	min 12% 0 2, Max 5% C 0 2			Min 10% 0 2; Max 5% CO2
STREAMING AGENTS				
Halon 1211		0.5%	1.0%	
C6F14		40%	>40%	

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TOTAL FLOODING AGENTS

USE CONDITIONS

a. If personnel cannot evacuate in less than 1 minute, design concentration may not exceed cardiotoxic "no observed adverse effect level (NOAEL)."

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TOTAL FLOODING AGENTS

USE **CONDITIONS**

b. If personnel can evacuate in less than 1 minute, design concentration may be up to the cardiotoxic "lowest observed adverse effect level (LOAEL."

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TOTAL FLOODING AGENTS

USE **CONDITIONS**

c. Design concentrations greater than the "lowest effect level" are only permitted in areas not normally occupied, where people can evacuate within 30 seconds.

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UPCOMING WORK

- Health & Safety Issues
  - CNS Effects
  - Potential exposure profiles of water mists and of powdered aerosols
  - Minimum Oxygen levels for inert gases, excluding added CO,

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ENVIRONMENTAL CRITERIA

- Ozone Depletion Potential

  class I: ODP 0.2 or higher

  class 11: determined by the EPA Administrator

  currently, 0.02 lowest ODP listed

- Global Warming Potential
- Atmospheric Lifetime

Context: Climate Change Action Plan - Action #40

AGENT	ODP	100 yr. GWP	500 yr. GWP	ATMOSPHERIC LIFETIME
Carbon Dioxide	0	1		120
HFC-23	0	9,000	8,400	300
HFC-227ea	0	2,050	736	31
C4F10	0	5,500	8,514	3,000
HCFC Blend A	0.05-0.02	90-1,608	30-540	1.6-15
IG-541	0	N/A	NIA	
Halon 1211	3-4			12-18
C6F14	0	5,200	7,416	3,000
HCFC Blend B	0.02	90		1.6

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TOTAL FLOODING AGENTS

NARROWED USES of PFCs

- Acceptable only where no other alternative is technically feasible due to safety or performance
- User must evaluate alternatives and keep records of evaluation

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UPCOMING WORK

- **Environmental Issues**

  Controlling unnecessary emissions of greenhouse gases, ozone depleters and persistent long-lived gases

- **CF_3I work in progress**

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ACCEPTABLE TOTAL FLOODING AGENTS

FEASIBLE IN NORMALLY OCCUPIED AREAS

- **HFC-23 (FE 13)**
- **HFC-227ea (FM 200)**
- **C4F10 (PFC 410) ***
- **[HCFC BLEND] A *(NAF* S III)**
- **[Inert Gas Blend] A (Inergen)**

* **restricted use**

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OTHER ACCEPTABLE TOTAL FLOODING AGENTS

FEASIBLE IN NORMALLY UNOCCUPIED AREAS

- HBFC-22B1 (Great Lakes FM100)
- HCFC-22
- HCFC-124 (DuPont FE-241)
- HFC-125 (DuPont FE-25)
- HFC-134a (DuPont)
- Powdered Aerosol (Spectrex)
- Solid Propellant Gas Generator (Rocket Research)

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TOTAL FLOODING AGENTS

PENDING

- Water Mist (Securiplex; Yates)
- Powder Aerosols (Spectrex; Survice)
- Inert Gas Blends (Securiplex; Minimax)
- SF6 (Discharge test agent)
- C_3F_8 (3M CEA-308; PFC-218)
- Fluoroiodocarbons (CF_3I)

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SUMMARY OF STREAMING AGENTS

COMMERCIAL & MILITARY USES ONLY

- [HCFC BLEND] B (Halotron I)
- HCFC-123 (DuPont FE-232)
- C6F14 (3M PFC 614) *
- HBFC-22B1 (Great Lakes FM 100)

* restricted use

EPA

STREAMING AGENTS

PENDING

- HCFC-124 (DuPont FE-241)
- HFC-134a (DuPont)
- HFC-227ea (Great Lakes FM-200)
- HCFC/HFC Blend (NAF P III)
- HCFC blend (NAF Blitz III)
- Powdered Aerosol/HFC or /HCFC blend (Powsus)

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ESTIMATED U.S. BANK

HALON 1301	**27,000,000 kg (29,000 tons)**
HALON 1211	**24,000,000 kg (26,000 tons)**

EPA

HALON BANKING POLICIES

EPA ENDORSES:

- **HALON RECYCLING CORPORATION (HRC) - non-governmental organization**
- **US DEPARTMENT OF DEFENSE RESERVE**
- **UNEP HALON BANKING CLEARINGHOUSE**

GOAL: BEST USE OF HALON THROUGH INTERNATIONAL TRADE, AND

NO ESSENTIAL USE EXEMPTIONS

EPA

EPA ENFORCEMENT ALERT

Imports of illegal halons

Montreal Protocol
free trade across international border of recycled halons

U.S. Clean Air Act
definition of recycled halon: must have been recovered from a 'use' system

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U.S. Clean Air Act

Accelerated Phaseout Schedule

Class II Substances

	New Systems	Existing Systems
HCFC-141b		2003
HCFC-22; HCFC-142b	2010	2020
All Other Class II Substances	2015	2030

*HCFCs may not be used in aerosol products or pressurized dispensers.
*HCFCs may only be used in portable Fire extinguishers if alternatives are less effective.

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